What *Is* This Stuff?

Preparation Time:	**Easy-to-do**	Moderate	Extensive

9.AIR.9

Grade:	9 – 10
Focus:	Air pollutants and their sources
Subject:	Environmental Science, Biology
Materials:	Student worksheets
Teaching Time:	Two class periods
Vocabulary:	Ambient, pollutant

Learning Objective
Students will:

- investigate six major pollutants including major sources and effects;
- list ways to reduce air pollution.

Background
See the Resource section for information and ideas on things you can do at home to reduce air pollution and conserve our resources.

The U.S. Environmental Protection Agency sets air quality standards so that even people who are the most sensitive to air pollution, usually the very young, old, or sick, do not suffer adverse health effects from air pollution. The National Ambient Air Quality Standards were set for substances identified as "criteria pollutants," common, widespread pollutants shown by research to be harmful to human health and to general public welfare. "Welfare" includes crops, livestock, vegetation, buildings and visibility. **Ambient** means the air around us.

Carbon monoxide, lead, nitrogen oxides, ground-level ozone, particulate matter, and sulfur dioxide are the criteria pollutants.

Many efforts are underway to reduce air pollution. Air pollution control devices are being installed in factories, power plants, vehicles, and even wood-burning stoves to trap pollutants before they get into the air. Using cleaner burning fuels and more advanced combustion technology help reduce pollution. Other efforts include encouraging people to use cars less and to conserve electricity. This will reduce the amount of fuel we burn and, at the same time, reduce the amount of pollutants we put into the atmosphere.

Learning Procedure

1. Remind students that the atmosphere is necessary for plants, animals and humans to live. The atmosphere is only a thin layer of air, roughly comparable to the skin of an apple. Natural air pollution caused by volcanoes and forest fires has always existed. Naturally produced pollutants are present in greater amounts than pollutants from human origin. Because they are less concentrated and, in many cases, less toxic than pollutants resulting from human activities, natural pollutants do not present as serious a problem as human-made pollutants do.

   Modern society uses large quantities of fuel to produce electricity and power vehicles and also engages in industrial activity, all of which results in air pollution. Not only are some of these pollutants very harmful, but the activities producing them are often carried out in urban areas, increasing their concentration in places where many people live and work. We have no

DOWN to Earth

DATELINE: January 1, 1992, Utah County, Utah - According to the Salt Lake City News, doctors claim about 50 Utah County residents die each year because of air pollution.

The Information Please Environmental Almanac, 1993

control over natural pollutants, but we can control human-made pollutants. As humans produce even more pollutants, control and reduction of them becomes increasingly important … and difficult.

2. Introduce the term **pollutant** and identify air pollutants as chemical or materials that change the air so that its use is impaired in some way. Tell the students that many air pollutants come from burning coal, oil, wood, and other fuels. We use these fuels to run factories, cars, and power plants that generate the electricity that heats and lights our homes. Other pollutants come from industrial and manufacturing processes. These are typically released in much smaller quantities but are generally much more toxic. Regardless of their source, these pollutants are a byproduct of today's lifestyle … a lifestyle that we enjoy and expect. Totally eliminating these pollutants would require drastic changes in lifestyle … changes most of us would rather not make.

   Ask the students to name any air pollutants, natural or human-made.

3. Present the following information on each of the six major pollutants. Remind them that these are "criteria pollutants" and are regulated at the federal level by the EPA. The following descriptions are from the US EPA.

   - **Carbon Monoxide:** A colorless, odorless gas emitted when vehicles burn fuel. It is also given off by kerosene or wood stoves used to heat homes. The effects of carbon monoxide include headaches, reduced mental alertness, and heart damage. It may even cause death by reducing the oxygen-carrying capacity of red blood cells.

   - **Lead:** Formerly a problem when all cars used gasoline with lead additives. When leaded gasoline is burned, lead is released into the air. Some industrial processes also result in lead air pollution. When people or animals breathe lead over a period of time, it accumulates in their bodies and can cause brain or kidney damage. Today most cars use unleaded gasoline, and the use of lead additives has been phased out in South Carolina.

   - **Nitrogen Dioxide:** Is a light brown gas at low concentrations. In higher concentrations it becomes a major component of brown urban haze. Nitrogen dioxide is the result of burning fuels from utilities, industrial boilers, cars, and trucks. It is one of the major pollutants that causes smog and acid rain. In high concentrations, it can harm people and vegetation. In children it may cause increases in respiratory illness such as chest colds and coughing. Asthmatics may suffer from more difficult breathing.

   - **Particulate Matter:** Soot, dust, tiny droplets of liquid, and other materials. It is sent into the air usually by burning coal, diesel fuel, or wood. Particulates gradually settle back to the earth and can cause people to cough, get sore throats or develop more serious breathing problems. They can affect animals and plants. The smaller the particulates, the more easily they can travel deep into the lungs, causing more harm.

   - **Sulfur Dioxide:** Emitted by power plants and factories that burn coal for fuel. Sulfur dioxide is the main sulfur oxide pollutant. It can harm human and animal lungs, as well as all kinds of plants. Sulfur dioxide is a main contributor to acid rain. It reacts with oxygen in the air to become sulfur trioxide which then reacts with water in the air to form sulfuric acid. Acid rain can harm animal populations in lakes and rivers as well as trees and plants by damaging leaves and root systems. It can deteriorate metal and stone on buildings and statues. Acid-forming dry particles can also fall to earth. The effects of acid rain are not only local, they can also occur hundreds of miles away from their source.

4. Give each student a copy of the work sheet (included). Have the students complete the sheet by selecting the correct sources and effects from the information provided above. The answers are as follows:

   - **Carbon Monoxide:** Sources: cars, wood stoves; Effects: less oxygen in blood, reduced mental alertness, heart damage.
   - **Lead:** Sources: coal-fired electric power plants, metal refineries, lead consuming industries such as battery manufacturers; Effects: brain damage, contaminated crops and livestock that then introduce lead into our food chain.
   - **Nitrogen Dioxides:** Sources: cars, coal-burning stoves, coal-fired electric power plants; Effects: lung damage, damaged forests, smog.
   - **Ozone:** Source: vehicles (formed mainly from pollutants in exhaust), other sources of ozone-forming fumes such as gas stations, paints; Effects: eye irritation, respiratory tract problems, lung damage, damaged vegetation, smog.
   - **Particulate Matter:** Sources: diesel engines, windblown dust, wood stoves; Effects: lung damage, eye irritation, reduced visibility, discolored buildings and statues.
   - **Sulfur Dioxide:** Sources: coal-burning electric power plants, coal-burning stoves, refineries; Effects: eye irritation, lung damage, harmed aquatic organisms, damaged forests, deteriorated buildings and statues. (These effects are largely due to acid rain.)

Extension Activities

1. Write to the U.S. EPA and DHEC to request information on major air quality legislation, including major changes in recent years.
2. Invite a representative from a local power plant to discuss air pollution control efforts and how they have changed in the past 10 years.
3. Research what air pollutants South Carolina industries release and how are they monitored.
4. Research the “killer smog” in London in December 1952 that resulted in the deaths of more than 4,000 people.
5. Trading Emission Credits: In March 1993, the U.S. EPA created a system that allows the nation’s 110 worst polluting power plants in 21 states to buy, sell or trade unused sulfur dioxide emission credits. The EPA-created the system in an attempt to encourage utilities to invest in better anti-pollution equipment. The long-range goal of the program is to cut acid rain in half by the year 2010. The EPA issues credits that are based on the power plant’s size. For example, if a corporation is assigned 10,000 credits, it can legitimately release 10,000 tons of sulfur dioxide into the atmosphere annually. If this plant has purchased the latest anti-pollution equipment and it releases only 6,000 tons, the company still has 4,000 credits. These credits can then be sold to another utility to help it recover its costs for the purchase of the new equipment.

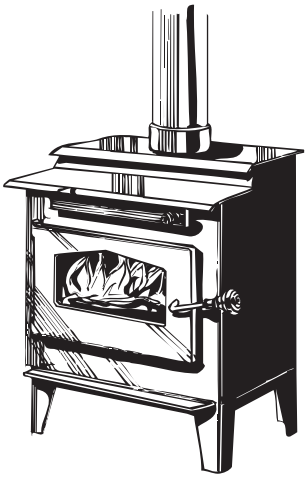
   Ask: Why are utilities big contributors to acid rain? What causes this form of pollution? What is the EPA’s reasoning behind the creation of this long-term program? How can power companies reduce the level of sulfur dioxide they release into the atmosphere? Environmental activist organizations opposed this program from the very beginning. Since it appears to be a step in the right direction, why would these organizations be opposed to trading emission credits? Why would the EPA allow the trading of pollution credits on a stock exchange? Some environmental groups are buying these publically traded credits and taking them “out of circulation.” What do you think about that practice?

Particulate Matter

SOURCES:

Diesel Engines

Dry Cleaners



Windblown Dust

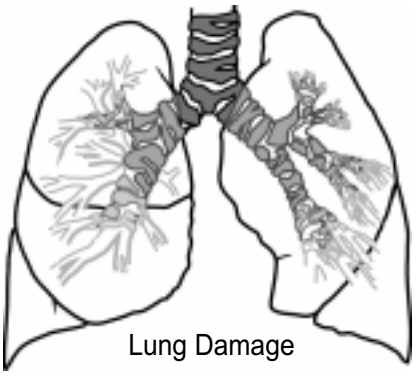
Wood-burning Stoves

EFFECTS:

Corroded Buildings and Statues

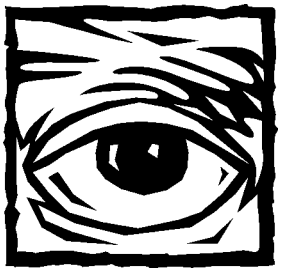
Brain Damage

Damaged Crops



Lung Damage

Eye Irritation

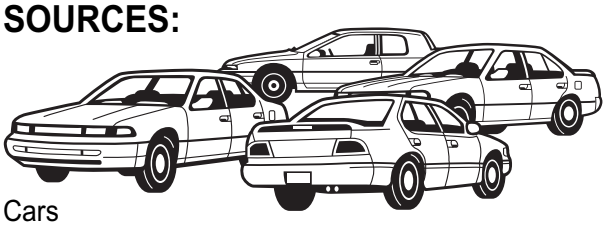


Reduced Visibility

STUDENT WORKSHEET

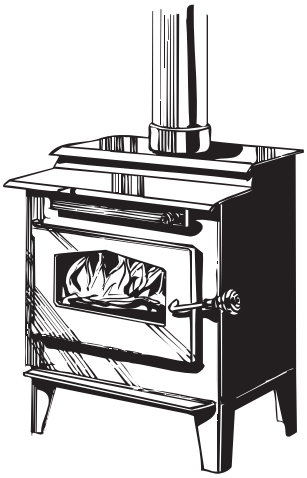
Carbon Monoxide

SOURCES:



Cars

Dry Cleaners



Wood-burning Stoves

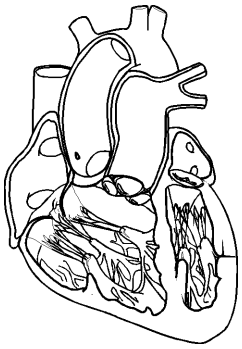
Windblown Dust

EFFECTS:

Corroded Buildings and Statues

Reduced Mental Alertness

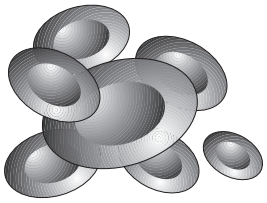
Global Warming



Heart Damage

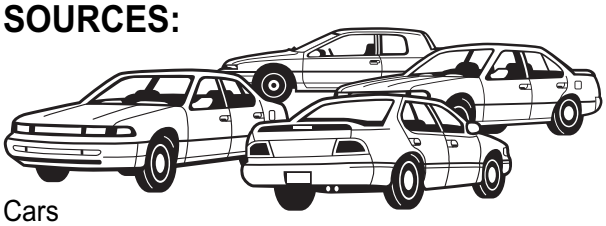
Smog

Less Oxygen in the Blood

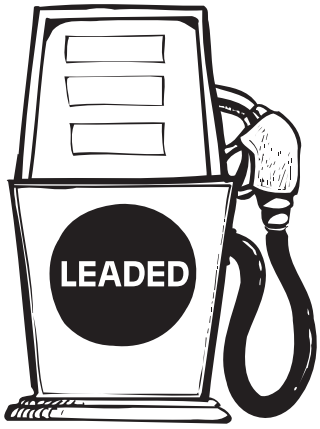


Lead

SOURCES:

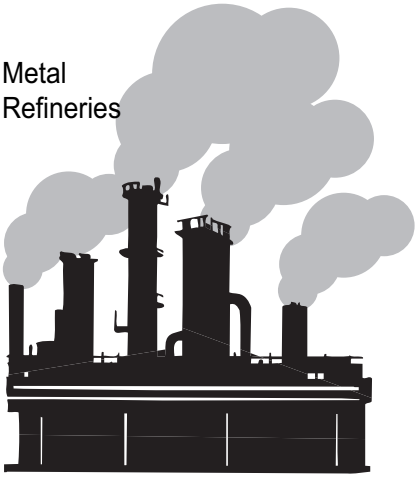


Cars



Leaded Gas

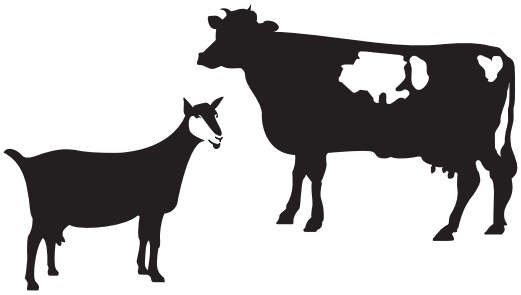
Metal Refineries



Electric Power Plants

EFFECTS:

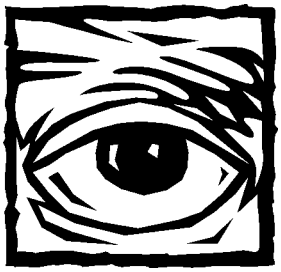
Contaminated Livestock



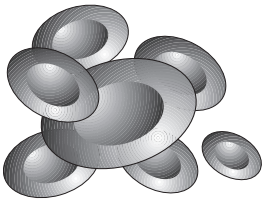
Contaminated Crops

Brain Damage

Eye Irritation



Less Oxygen in the Blood

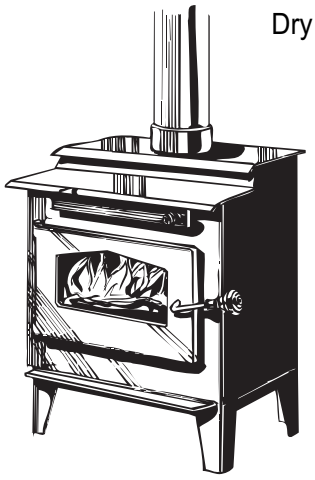


Smog

Nitrogen Oxide

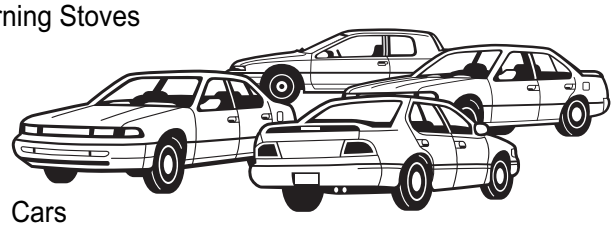
SOURCES:

Electric Power Plants



Wood-burning Stoves

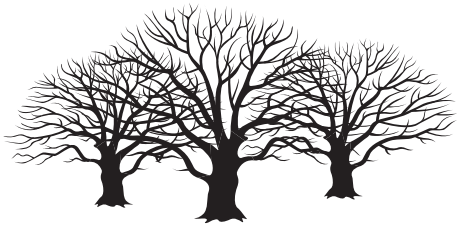
Dry Cleaners



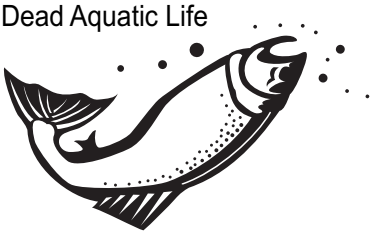
Cars

EFFECTS:

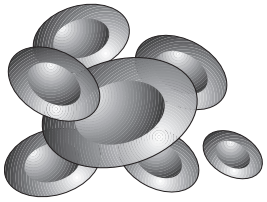
Corroded Buildings and Statues



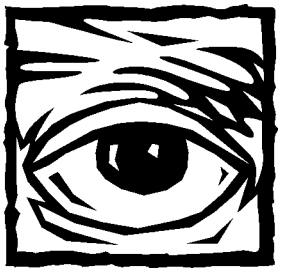
Damaged Forests



Dead Aquatic Life

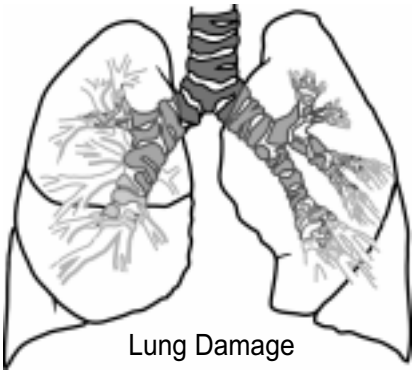


Less Oxygen in the Blood



Eye Irritation

Smog

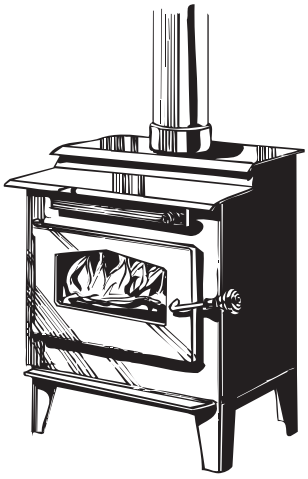


Lung Damage

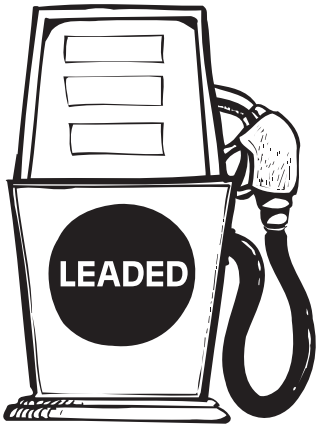
Ozone Sources

SOURCES:

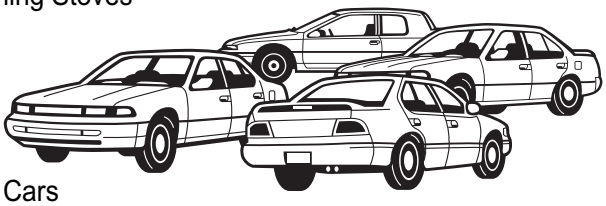
Electric Power Plants



Wood-burning Stoves



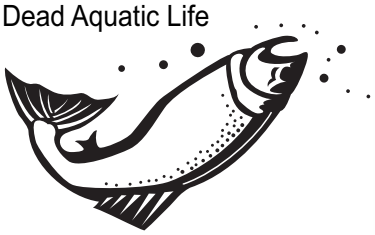
Leaded Gas

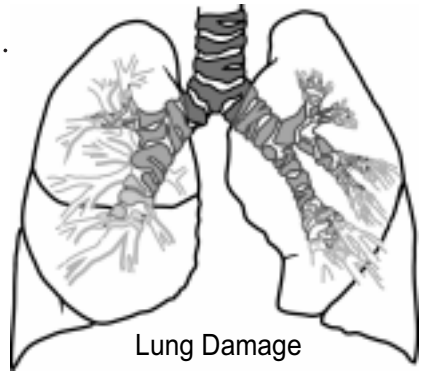


Cars

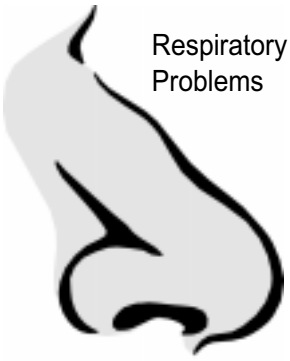
EFFECTS:

Dead Aquatic Life





Lung Damage

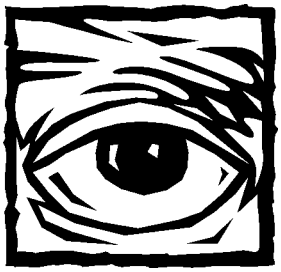


Respiratory Tract Problems

Contaminated Crops

Smog

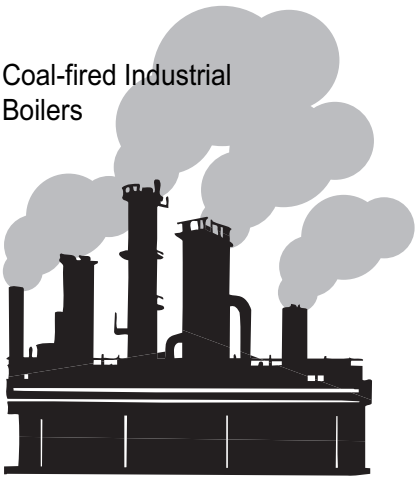
Eye Irritation

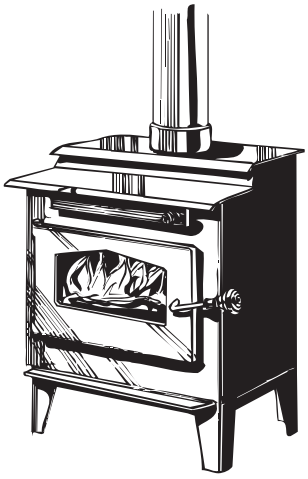


Sulfur Dioxide

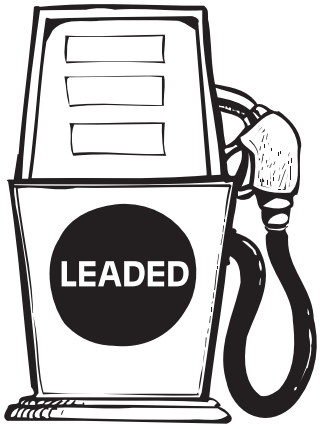
SOURCES:

Coal-fired Industrial Boilers





Wood-burning Stoves

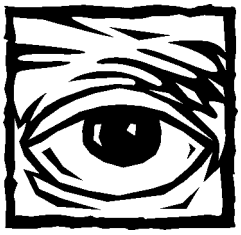


Leaded Gas

Electric Power Plants

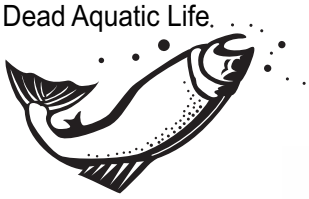
EFFECTS:

Corroded Buildings and Statues

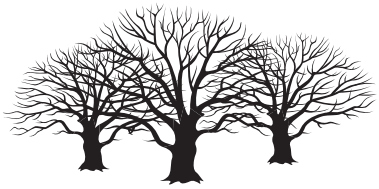


Eye Irritation

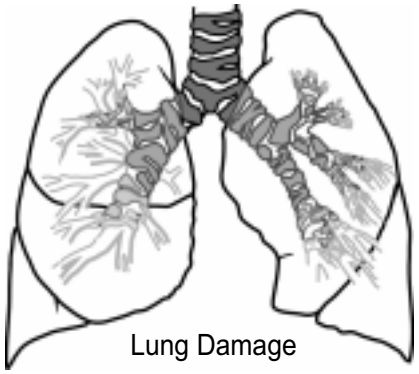
Dead Aquatic Life.



Damaged Forests



Smog



Lung Damage

Concentrations of some toxic and cancer-causing pollutants can be as much as 100 times greater indoors than outdoors. Open the windows once in a while to let some fresh air breeze through the house … and your classroom.

Who's in Charge Here?

Preparation Time:	**Easy-to-do**	Moderate	Extensive

9.AIR.10

Grade:	9 – 10
Focus:	Environmental Watchdogs
Subject:	Science, Government, Social Studies
Materials:	Transparency *Timeline*
Teaching Time:	One class period, out of class research

Learning Objective
Students will:

- research the history of environmental regulations in the United States and their historical context;
- research environmental regulatory and enforcement agencies on both the national and state level.

Background
The 1970 Clean Air Act set a 1975 deadline for eliminating 90 percent of all automobile emissions, established by the U.S. Environmental Protection Agency (EPA). Also introduced in 1970 was the Resource Recovery Act and the concept of resource recovery as an alternative to land disposal. This was major environmental legislation. However, the U.S. passed its earliest environmental laws in 1948, the Water Pollution Control Act. By this time, the Industrial Age had been in full swing for nearly 75 years.

Learning Procedure

1. Show the transparency, *Timeline*, and discuss some of the technological advancements and environmental laws.
2. Have the students research and report on the formation and responsibilities for the US EPA and the S.C. Department of Health and Environmental Control. Your County Library is an excellent source for this material. The various divisions of DHEC produce annual reports and many are available in libraries across the state. Have students find out the difference between regulations and enforcement, who makes environmental laws, why environmental laws are made, have environmental laws changed over the years and why?

   To help students' with their investigations, they can call the the DHEC Resource Center in Columbia at 1-800-SO-USE-IT.

DOWN to Earth

The use of catalytic converters in automobiles has reduced emissions of carbon monoxide, nitrogen oxides, and volatile organic compounds in the United States, Canada and Japan. These, however, are just beginning to come into use in Europe.
The Information Please Environmental Almanac, 1992

Environmental Timeline

1809 **Food canning** was developed by Nicholas Appert. Today, $1 out of every $11 spent for food goes for packaging which makes up 1/3 of what we throw away. And much of this packaging lasts virtually forever in landfills.

1883 **Rayon** synthetic fiber was first manufactured as artificial silk for clothing by Comte Hilaire de Chardonnet. It was displayed at the Paris Exhibition of 1889. Today, rayon is one of many synthetic fibers used in clothing. Hazardous waste is a byproduct of its production.

1839 **Vulcanized rubber**, a more durable, flexible rubber was invented. Today, nearly 2 billion tires are stockpiled in the United States. Efforts from the industrial community promote recycling old tires.

1889 **Gasoline-fueled automobile:** By 1908, 241 automobile-manufacturing firms were in business in the United States. Ford produced 1,700 cars its first year. Today, three million cars are abandoned every year in the United States.

1899 **U.S. Rivers and Harbors Act or Refuse Act** made it a crime to dump any liquid wastes except those from sewers into navigable waters. The law could have been extremely effective in lessening water pollution, but it was not enforced for the next 50 years.

1911 **Air conditioning:** A dust filter is combined with Wallis Carrier's 1902 cooling device and is used in a textile mill to condition cotton with air. Today, CFC coolants in car air conditioners are responsible for 16% of the ozone layer depletion. CFC's released today will take 8 - 12 years to reach the ozone layer.

1930s **The Age of Plastics** saw the turn from natural to synthetic materials. Today, although many plastics are recyclable, they take up about one-third of landfill space. **Polystyrene,** resistant to many chemicals, was used in electrical insulation and toilet articles. Polystyrene is non-biodegradable, and cups and plates last virtually forever in landfills. **Nylon** was the first real synthetic yarn. Besides stockings, it is used for almost everything from carpeting to toothbrushes to seat belts to artificial fur. **Silicone** products were hailed for their resistance to heat and other substances. Today, silicone is used for many things, including spare body parts from heart valves to cosmetic implants.

1934 **First major laundry detergents** sold. Today many household cleaning products are considered hazardous.

1937 **The Snowmobile** was invented by J. Armand Bombardier

1940 **DDT**, a chlorinated hydrocarbon, was used as a "miracle" pesticide. It was banned in 1972 when it was determined that DDT was contaminating the food chain with poison that would have lasting effects.

1941 **Penicillin** was first used to treat a human being. Today, hazardous waste is a by-product in the creation of many synthetic wonder drugs.

1948 Original federal **Water Pollution Control Act** was passed in the U.S. It said that waste disposal is a fundamental use of water.

1951 **Disposable diapers** were introduced. Today, the average baby generates a ton of garbage a year.

1955 **U.S. Air Pollution Control Act** took effect.

1956 **Water Pollution Control Act Amendments** authorized states to establish water quality criteria.

1963 Original **Clean Air Act** passed to curb air pollution from industry.

1964 **Biodegradable detergents** were announced offering an alternative to water polluting phosphate ingredients.

1965 **Amendments to Water Quality Act** placed limits on discharges from individual sources and required that states establish and attain ambient water quality standards.

1969 **National Environmental Policy Act** passed requiring environmental impact statements for all federal projects.

1970 **The first Earth Day** took place on April 22. Citizen groups rallied to demand more information and research on our environment and action against pollution.

1970 **Clean Air Act Amendments** set 1975 deadline for eliminating 90% of auto emissions.

1970 **U.S. Environmental Protection Agency** established.

1970 **Resource Recovery Act** established resource recovery as an alternative to land disposal.

1971 **Federal Hazardous Substances Act** identifies hazards and sets bans on certain substances.

1972 **Federal Water Pollution Control Act** set goals for fishable and swimable waters and required technology-based effluent standards on individual dischargers.

1972 **Federal Insecticide, Fungicide and Rodentcide Act** controls use of pesticides that could adversely affect ground water.

1974 **Safe Drinking Water Act** passed to ensure safety of public drinking water systems.

1975 **Hazardous Materials Transportation Act** required that shipments of hazardous materials must be packaged, labeled and transported in accordance with DOT rules, and required carriers to report spills.

1975 **The first home computer** revolutionized the computer industry. Computer chips are rinsed with toxic acids and most parts are made of plastic.

1976 **Resource Conservation and Recovery Act (RCRA)** established "cradle-to-grave" management of hazardous wastes tracking chemicals from manufacture to disposal.

1976 **Toxic Substance Control Act (TSCA)** passed, authorizing the U.S. EPA to gather information on chemical risks.

1977 **Clean Water Act** postponed some of the deadline set in 1972 and increased control of toxic pollutants.

1977 **Revision to Clean Air Act** set standards for hazardous air emissions and set controls for auto and vehicle emissions.

1980 **Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)/Superfund** was established to clean up abandoned hazardous waste sites or accidental spills.

1981 **Municipal Wastewater Treatment Construction Grant Amendments** passed for the financing of municipal sewage treatment, reduced federal share, changed allocation priorities and lowered authorizations.

1984 **Hazardous and Solid Waste Amendments to RCRA** eliminated land disposal of untreated hazardous waste for most chemical wastes.

1986 **Asbestos Hazard Emergency Response Act (AHERA)** required asbestos identification and development of abatement plans.

1987 **Water Quality Act** further postponed deadlines for technology-based effluent standards and transition from federal

grants to contributions to state revolving loan funds.

1990 **U.S. Clean Air Act**, the most far-reaching environmental legislation of its time, passed.

DOWN to Earth

Between 1900 and 1948, no significant environmental legislation was written. By the time we learned that hazardous waste management was needed, millions of tons of dangerous chemicals had already been released into our air and water, and onto our land.

Scales, Rules, Policy, Standards and Science

Preparation Time:	Easy-to-do	Moderate	Extensive

9.AIR/EPA.1

Grade:	9 – 12
Focus:	Air pollution, The Clean Air Act
Subject:	Science, Social Studies
Materials:	1 worksheet (included)
Teaching Time:	30 minutes
Vocabulary:	Scale, standards

Learning Objectives
Students will:

- identify methods to obtain information for developing standards;
- recognize conflicts that may exist between what people want and what can be achieved;
- translate objective and subjective data into standards.

NOTE TO TEACHERS: This exercise examines the role of opinions, values, attitudes, beliefs, and science on the development of standards. Students will answer a series of abstract questions designed to demonstrate how a standard is developed. Students also will answer questions related to ecological standards. From the results of the survey, classroom-wide standards will be developed to reflect the "consensus" of the class.

Background
Governments rely on the development of standards as the basis of most regulations. For example, most environmental regulations are based on public or environmental health standards that help gauge the dangers posed by a certain level of pollution or contamination. However, people should understand that such standards are not purely scientific: "hard" scientific data is always subject to the political process before it is written into regulations. What's more, there is often much disagreement within the scientific community over the data itself. Standards, then, are the result of these processes.

This exercise poses the question "How do we decide what a standard should be?" and focuses on the interplay of personal belief, opinion, and scientific facts and evidence in the development of standards and rules. Air quality policy and regulations are a result of the synthesis of scientific information and public attitudes and values. What costs people are willing to tolerate to maintain air quality is as critical to the development of air quality standards as the scientific health risks posed by air pollution.

In one sense, an air pollution standard reflects how much air quality the public is willing to buy. Often, there is a conflict between what people are willing to tolerate and what may be good for them. For example, smog is a major health concern in southern California, but people in Los Angeles have consistently resisted the imposition of restrictions on automobile driving even though auto exhaust is a major factor in smog production. Between the two extremes on this issue lies a position which, presumably, most people would be willing to adopt. This exercise demonstrates how such conclusions are reached. (See reading materials on "The Clean Air Act" and "Air Pollution" in the Appendix)

Learning Procedure

1. Discuss scales and methods by which things are measured: size, weight, volume, time, temperature. For example, time passes whether or not it is broken up into days. Discuss how it is reduced to discrete units (days, hours, weeks, years) in ways that all agree upon so that it may be used. In what ways are scales and measures useful? (Answer: so that one thing may be compared with another thing.)

2. Discuss standards and where they come from. For example, how would your class decide what the temperature of the room should be? Each person could be asked, and the result would be a range of temperature values. From there, the statistical mean temperature would represent a "fair" determination of the classroom-wide consensus. Mention Goldilocks and the Three Bears and the "just right" standard. How do we know what is "just right?" What effect does custom and convention have on an individual's belief?

3. Discuss the concept of rules and how standards are fashioned into rules. Ask students for examples of rules that govern their lives. What is the rationale for these rules? Distinguish the roles of objective facts and subjective beliefs. For example, young children may have a certain bedtime. Is this the result of extensive studies on the effects of sleep deprivation or because parents think it is a good idea? Discuss how sound rule-making requires information collection and the application of shared values.

4. Distribute the student worksheet. Ask each of the survey questions and have students mark their answers. Collect and tabulate the results. Discuss how to determine the classroom-wide standards based on the results? Discuss the tradeoffs that are inherent in developing standards based on opinions and beliefs rather than strictly scientific conditions. (For example, how did they decide how much is "too much" pollution?)

5. Discuss the roles of scientific evidence and personal belief in answering these questions. Ask individual students what led them to answer a question in a certain way. Select students who answered the same question in opposite ways to "make their case."

Extension Activity

For grades 10 through 12, have students follow up this exercise by researching how generally accepted standards get translated into government policies, regulations, or laws. Have them make short presentations of their findings.

Suggested Reading

"Green, Greener, Greenest." *Economist,* 311 (6 May 1989) p. 67.

This lesson was adapted from the EPA publication Project A.I.R.E. – Air Information Resources for Education (K-12).

STUDENT WORKSHEET

Scales, Rules, Policy, Standards, and Science Survey

This questionnaire will be used to determine a classwide standard for a healthy environment. It also will ask questions about what individuals would be willing to do to achieve a healthy environment.

AIR POLLUTION: HOW MUCH IS TOO MUCH?
(circle one response)

1. Air pollution is not a major problem in the United States.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

2. Air pollution is not a major problem in our town.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

3. Air pollution should be reduced to levels that do no harm to the environment or to people.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

4. Air pollution should be reduced to levels that do no harm to people and the environment regardless of cost.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

5. There is a safe level of air pollution (that is, some level of air pollution should be tolerated).

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

6. A safe level of air pollution should be achieved regardless of cost.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

7. The cost of air pollution reduction and prevention should determine the amount of pollution permitted.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

8. Activities that pollute the air should be prohibited.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

AIR POLLUTION:
WHERE DOES IT COME FROM?

1. Human activity is the source of most air pollution.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

2. Visible air pollution is the most significant problem.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

3. Most air pollution is the kind that can be seen coming from smokestacks.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

4. Most air pollution is emitted from automobiles.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

5. If it can not be smelled or seen, it does not matter.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

AIR POLLUTION: WHAT IS THE SOLUTION?

1. I am willing to change some of my everyday habits and ways of doing things that may cause air pollution (for example, conserve energy, use mass transit rather than drive, purchase environmentally friendly products).

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

2. I am willing to pay reasonably higher prices when necessary if it will help reduce air pollution.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

3. Future changes in technology will probably eliminate most causes of pollution by the time I am an adult.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

4. I am willing to have the government tell me how to reduce pollution.

   1 - strongly agree
   2 - agree
   3 - neutral
   4 - disagree
   5 - strongly disagree

Tracking Air Quality

Preparation Time:	Easy-to-do	**Moderate**	Extensive

9.EPA/AIR.2

Grade:	9 – 10
Focus:	Weather, air quality
Subject:	Science, Math
Materials:	Five sheets of white (or light colored) poster board or heavy construction paper each measuring 2 feet by 2 feet, Felt-tip markers in black, green, blue, red, purple, orange (1 in each color)
Teaching Time:	Class #1: 15 minutes; Classes #2 - 5 (over 2 to 6 week period): 5 minutes each; Class #6: 40 minutes
Vocabulary:	Air Quality Index, carbon monoxide, criteria pollutant, lead, nitrogen oxides, ozone, particulate matter, precipitation, relative humidity, sulfur dioxide, temperature, thermal inversion

Learning Objectives
Students will:

- observe the impact of weather on air quality;
- demonstrate data gathering, analysis, graphing, and presentation

NOTE TO TEACHER: This exercise lets students graph changes in the weather that have implications for air quality in the community. This exercise is best conducted over a long period of time (especially in the Fall) in order for students to observe significant variations in the Air Quality Index and correlate them with weather parameters.

Background
Graphing—the ability to depict information, relationships, and trends—is a basic skill for communicating ideas and sharing information. It is a skill that supports endeavors in science and mathematics. It is with graphical analysis that scientists and engineers at EPA look for relationships and processes that are not immediately apparent with single, one-time measurements.

Conceivably, this activity could be conducted through out the year or periodically to build a data set large enough to establish seasonal trends and determine indicators of change. When the same collecting techniques are applied to air pollutants, the accuracy, frequency, location and testing protocol become critical for obtaining useful data with which to explain the movement of pollution in the environment and the extent to which we are exposed to air pollutants.

Pollutants in the air come from many sources. Natural air pollution caused by volcanoes, forest fires, and other natural sources has always existed, and naturally produced pollutants are present in greater amounts than those made by humans. They do not present as serious a problem as man-made pollutants, however, because they are dispersed over large areas and many are less harmful. Air pollutants from man-made sources are the result of our increasing use of large quantities of fuel to produce electricity and to run everything from factories to automobiles and other vehicles. Not only are some of these pollutants very harmful, but also they tend to be concentrated in urban areas where most people live and work. Six of the major man-made pollutants—sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, lead, and particulate matter—have been designated “criteria” pollutants and are regulated by the federal government.

Daily weather conditions directly affect whether and how much we are exposed to pollutants in the air. Shifting air masses (weather systems) and

wind can move pollutants from one place to another. On the other hand, stationary air systems, like thermal inversions, can trap harmful pollutants over an area for days at a time. Rain, snow, and other forms of precipitation help wash pollutants from the air and onto the ground. While precipitation cleanses the air we breathe, it also may increase pollution of the land and surface water.

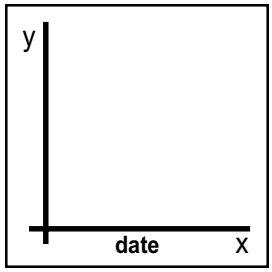
Meteorologists use the Air Quality Index to classify and measure contaminants in the air and report conditions to the public. The index is used to convert data from air monitoring stations at various locations around a community to a scale that indicates the potential effects of measured levels of various contaminants, including the "criteria" pollutants (listed above), on human health, property, and vegetation. This information enables local government officials to take appropriate protective steps in harmful conditions like thermal inversions and smog.

Learning Procedure: Class 1

1. Divide the class into five teams and assign each team one of the following five weather parameters: Temperature, Wind Direction, Precipitation, Air Quality Index, and Relative Humidity.

2. Explain that each team will record daily changes in these aspects of the weather on posted graphs over a period of time (specify the period). At the end of the selected period, each team will prepare their findings and make a short presentation defining the aspect of the weather they have been tracking. Where appropriate, students should record the range of values (for example, the high and low temperatures for the day) and a mean value.

3. Give each team a sheet of poster board. Instruct them to draw a graph on their posters that will allow them to track published information about the weather aspect they have been assigned. (Teams should share the black markers for this task.) The "x" axis for all the graphs should be "date."



4. Encourage students to call the local weather bureau or the weather reporter at the local television station for help in determining the appropriate "y" axis range for the parameter they have been assigned. Suggest that the students obtain data to fill in their graphs from the local weather bureau, weather reporter, or newspaper.

5. Hang or otherwise display the posters in the classroom where students can see them and record data on them each day. The teams should be given the flexibility to organize themselves to ensure that the recording of data is accomplished every day.

Learning Procedure: Classes 2 - 5

1. Take five minutes during each class to call attention to the status of the graphs and give students a few questions to consider in preparation for the discussion at the end of the exercise. For example: Would you expect some aspects of the weather to have more (or less) influence on the quality of the air we breathe? If so, which ones and why? The Air Quality Index is usually expressed for particular contaminants—such as ozone, sulfur dioxide, and ragweed pollen. From your observation, does it appear that changes in weather have more (or less) effect on air quality for some contaminants? If you have found no correlation, does that mean there is no effect? Is there another, better approach for determining a correlation?

2. During one of the classes near the end of the data collection period, give students a few additional questions to address in the presentations to be made in the final class. For example: How would you describe the weather in our area? What causes the weather to be like it is? Is the weather different elsewhere? If so, what causes it to be different in different places? Suggest that students brainstorm with their team-mates and present the group's perspective in their presentations.

Learning Procedure: Class 6

1. Before teams prepare their data for presentation, repeat the questions you posed during the periodic status checks—Would you expect some aspects of the weather to have

more (or less) influence on the quality of the air we breathe? If so, which ones and why? The Air Quality Index is usually expressed for particular contaminants—such as ozone, sulfur dioxide, and ragweed pollen. From your observations, does it appear that changes in weather have more (or less) effect on air quality for some contaminants? Encourage discussion.

2. Have each team make 5-minute presentations defining the weather parameter they have been assigned, reporting on the data collected, and addressing the general questions you posed in an earlier class (see item 2 in the previous section).

3. Ask the teams to compare the graphs. Now that they have seen all the data, ask if they would change their answers to any of the questions discussed at the beginning of class. Ask them to explain why (or why not).

4. Give each team one of the colored felt-tip markers. Encourage students to use the markers to point out similarities (or wide variances) between data on different graphs to illustrate and support their answers.

5. Encourage students to discuss what the results of this exercise might mean (for example, if the data collection period is "typical" for this time of year, how the weather might stress people with asthma or other respiratory problems, and how it might affect plants and trees in the area, or even their pets.) Have them discuss possible options for making the air quality better in these kinds of weather conditions.

6. Ask the students how they would determine whether their assumptions and conclusions are correct. End the class by recording on the chalkboard a list of their ideas. (The list should include going to the library to do research and talking to the local weather bureau, meteorologists, physicians, or local Health Department personnel.)

Extension Activities

1. Assign each team to act on one of the ideas offered for verifying the validity of conclusions and write a report to present in class.

2. Look up historical weather data (go through local newspapers or other sources recommended by the weather bureau) for the same period in previous years. See if a pattern or relationship can be found between the conditions in previous years and the data collection period for this exercise by graphing the historical data in the same manner as the current data and comparing it with the current graphs.

Suggested Reading

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Gibbons, Gail. *Weather Forecasting.* New York: Chelsea House Publishers (1992).

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This lesson was adapted from the EPA publication Project A.I.R.E. – Air Information Resources for Education (K-12).

DOWN to Earth

Almost 2 million tons of paper were recycled in South Carolina in 1998.

Source: 1998 Solid Waste Management Plan

Deciding to Clean the Air

Preparation Time:	Easy-to-do	Moderate	Extensive

9.AIR/EPA.3

Grade:	9 – 12
Focus:	Air pollution, automobiles and air pollution
Subject:	Science, Social Studies
Materials:	One worksheet (included)
Teaching Time:	Two class periods
Vocabulary:	Acetaldehyde, auto emissions, benzene, carcinogens, clean fuel, criteria pollutants, formaldehyde, hydrocarbons, nitrogen oxides, non-attainment area, ozone, particulate matter, smoke, soot, standards

Learning Objectives
Students will:

- understand the impact of choices on the nature and quality of life;
- understand the process for making decisions;
- recognize that different people have different perspectives on the same air pollution issue by researching, comparing ideas, considering alternatives, and making and justifying decisions.

NOTE TO TEACHERS: This activity lets students practice making choices and experience the sometimes difficult process of making decisions related to air pollution.

Background
Whether we are children or adults, our lives are influenced by a constant series of choices. Some choices we make for ourselves. Some choices are made by parents for their children, and many are made by people we don't even know. The combinations of all of these choices determine the quality of each of our lives. Making these choices is not easy because sometimes what a person perceives as the right choice for him or her as an individual may be perceived as the wrong choice for the neighborhood, the community, or the Nation. For example, a person may not want to join a car pool to get to school or work in the morning because it means coordinating his or her schedule with someone else's and, maybe, getting up earlier in the morning to be ready on time.

The combination of choices made by individuals, business and industry owners, and government over the years has had a huge impact on the quality of the air we breathe and the air pollution problems the world faces today. For example, as a country, we have chosen to pay the higher prices of cars with emission control systems in order to reduce pollution from motor vehicles.

Auto exhaust is a major contributor to air pollution. Automobiles emit several pollutants that EPA classifies as probable or definite carcinogens, including benzene, formaldehyde, acetaldehyde, and particulates (soot or smoke, especially from diesel vehicles). EPA estimates that toxic emissions from cars, trucks, and buses could be responsible for as many as 1,500 cases of cancer each year. (See reading material on "Automobiles and Air Pollution" in the Resource Section.)

In addition, automobile exhaust contains hydrocarbons and nitrogen oxides that react with sunlight to create ozone, the major component of smog. Ozone at ground level is responsible for the choking, coughing, and stinging eyes associated with smog. Ozone also inhibits plant growth and can cause widespread damage to crops and forests. In typical urban areas, at least half of the hydrocarbons and nitrogen oxides come from motor vehicles. Nitrogen oxides also are produced by power plants, factories, and even lawnmowers.

Hydrocarbons are found in many consumer products, including paints, hair spray, charcoal starter fluid, solvents, and plastic "popcorn" or "bubble" packaging. EPA sets national standards for ozone (one of the six widespread "criteria pollutants"), and the states must take action to ensure that standards are met. Areas that fail to meet the standards for at least one criteria air pollutant are called "non-attainment areas." (See reading material on "The Clean Air Act" in the Resource Section.)

Many of the smog clean-up requirements involve motor vehicles (cars, trucks, buses) because virtually everyone is exposed to their emissions. Also, as the pollution gets worse, pollution controls are required for smaller sources. Strategies that may be required by law to reduce and control these toxic emissions include state permitting programs, changes in the composition of gasoline, use of alternative fuels (such as natural gas and electricity), and use restrictions imposed by individual communities.

Many new and innovative approaches are being taken by local governments across the country to reduce air pollution in non-attainment areas. Some of these options include:

- banning charcoal barbecues and wood burning in stoves or fire places when pollution levels are high;
- developing high-occupancy vehicle (HOV) programs for local highways to encourage car pooling;
- restricting traffic in specific areas of the city;
- providing incentives for citizens to use public transportation systems;
- expanding public transportation systems using clean-fueled vehicles, such as municipal buses that use compressed natural gas (CNG) or electric trolley buses;
- eliminating payments by employers that reduce parking costs of employees who do not car pool;
- requiring employers to contribute to employee mass transit costs;
- assessing "smog fees" on cars in proportion to the number of miles driven and vehicle emissions produced;
- requiring more stringent vapor recovery at gas stations;
- requiring large companies to purchase fleet cars that run on clean fuel;
- buying and scrapping older cars.

Learning Procedure: Class 1

1. Explain that the class is going to act out a situation that illustrates the difficult process of making clean air choices. For the exercise, students are to assume that there has been a proposal brought before the city (town) council to close the downtown commercial district to automobile traffic because of the pollution level and traffic congestion. Under the proposal, only fire and police emergency and public transit (buses) vehicles would be allowed on downtown streets between the hours of 8:00 am and 6:00 pm.

2. Divide the class into 8 teams. Explain that each team will represent one of the "players" in this drama: three city (town) council members, two citizens, two downtown business owners, and one impartial expert that has been paid to evaluate the impacts of the proposal and report to the council (you may choose to be more specific about the roles to approximate the makeup of your community). Assign a role to each team and explain that each team will have to choose (not now) one team member to be the actor when the drama is played out at next week's class (give a specific date but allow a few days to prepare).

3. Explain that in order to act out the role they have been assigned, each team will have to define the characteristics and views of that person. Does the character live in the city (town) or out in the suburbs (in a rural area)? What does the person do for a living and where does he or she work? How does the person get to and from work? Does the person have a family? Where does the person shop? The last page of this activity is a sample "Character Attribute" worksheet that each team can fill out to help define its role.

4. Explain that once each team has defined its character, the team should define the character's concerns related to the proposal. Stress that this should go beyond deciding whether the character would be "for" or "against" the proposal and should include defining why this particular character might feel one way or the other. Encourage students to talk to their parents, local city (town) council members, and business owners to help develop these perspectives.

5. Explain that for the role-play activity, the actor from each team will have to describe the team's character and make a statement about that person's views on the proposal as if the character were addressing the council members during a meeting. (Remind the council members that they have a broader responsibility to the community and should be prepared, if necessary, to make a choice between their own individual views and what's best for the community as a whole.)

6. Give students the remainder of the class to work together and assign them to continue work outside of class in order to be prepared for the role-play activity.

Learning Procedure: Class 2

1. Arrange desks or a table at the front of the room with chairs to accommodate the three city (town) council members. Place a lectern, desk, or small table somewhere else in the room from which the expert, citizens, and business owners will make their statements.

2. Instruct the actor from each team to describe the team's character (based on the worksheet completed by the team). Have the expert deliver his or her impartial report to the council members and audience at the council meeting. Have the citizens and business owners state their views on the proposal. Have each council member make a similar statement.

3. Ask the council members to vote. Examine the results. How did each member vote? How did they decide what to vote? Discuss the results and the choices involved with the class.

TAKE NOTE! In the event that all teams take the same position on the proposal, be prepared to offer an opposing argument yourself, so that both sides of the issue will beheard by the class.

Extension Activity

Have students bring in examples throughout the year, from the newspaper or local television news, of real air pollution-related decisions made by your local government or major local businesses. Set aside time periodically to discuss the choices involved in these decisions and their impact on the quality of life.

Suggested Reading

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This lesson was adapted from the EPA publication Project A.I.R.E. – Air Information Resources for Education (K-12).

STUDENT WORKSHEET

Deciding to Clean the Air: Character Attributes

Name: _____

Family Members (include ages of children, if any): _____

Occupation (include type of business, if any): _____

Where do you live (in the city, suburbs, rural area)? _____

Where do you work (in the city, suburbs, rural area)? _____

How do you get to and from work? _____

How long does your commute take? _____

Where do you do the shopping? _____

Are there other occasions you need to be downtown during the restricted hours? _____

_____

What do you like about the proposal? _____

_____

_____

What don't you like about the proposal? _____

_____

_____

Are you for or against the proposal? How strongly do you feel about it? _____

_____

_____

Are there any modifications to the proposal you want to suggest to the council? _____

_____

_____